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Vitamin A Bioptency as Measured by Stores of Vitamin A in Livers of Feedlot Cattle

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Various research reports indicate that the potency of vitamin A in mixed feeds may be reduced with extended periods of storage. Commercially manufactured vitamin A premixes have a protective matrix which reduces rate of destruction of the vitamin and enhances its stability in mixed feeds. Routine assays of vitamin A content in feeds and biological materials usually employ a chemical assay such as the Carr-Price method or the USP (United States Pharmacopeia) method. Variations have been observed between these assay procedures in determining the vitamin potency in dry and liquid feeds. Discrepancies between chemical assays for vitamin A content and expected potency may be clarified by using animals under experimental conditions to check the biological potency. Storage of vitamin A in liver tissue most accurately measures the biological potency of vitamin A. Studies with large animals, however, are not usually feasible because of the time and costs involved.

The objective of these experiments was to evaluate the biological potency of two sources of vitamin A premix differing in freshness when administered to fattening beef cattle. Chemical assays were compared with blood and liver vitamin A content to measure the biopotency of the vitamin.

Procedures

Trial I

Twenty beef steers were used in this experiment. The steers averaged 1042 lb. and were allotted to three pens of six or seven steers each. The cattle had been used in a pasture experiment during the spring and summer months. Different levels of grain were fed in addition to pasture grazing. The cattle used in this trial were full-fed corn grain during the grazing period with an average daily intake of 16.4 pounds. Pasture growth declined by mid-October and the cattle were brought to the feedlot and fed an additional 56 days. The ration consisted of whole shelled corn and minerals (trace mineral salt, ground limestone and dicalcium phosphate offered in separate containers). No additional roughage was supplied.

The treatments consisted of administration of 600,000 IU (International Units) of vitamin A palmitate per steer per week for 4 weeks to give a total of 2.4 million IU per steer. One lot of seven steers received a recently manufactured vitamin A premix with a concentration of 325,000 IU per gram. A second lot of seven steers received a vitamin A premix which had been manufactured in early 1974 and kept in storage for general use. The premix label showed a vitamin A content of 30,000 IU per gram and this quantity was used as the basis for dosage. Chemical analysis of the premixes was conducted at the State Chemical Laboratory, Vermillion, South Dakota. The vitamin A premixes were administered in a gelatin bolus given to each steer with a balling gun. One

lot of steers received no supplemental vitamin A. Samples of blood were collected by jugular vein puncture at the start of the trial. Blood samples and liver tissues were taken at slaughter. Carotene and vitamin A analyses were performed on all samples.

Trial II

Thirty beef steers and heifers of mixed breeding were used in this trial. The cattle averaged 1083 lb. and were allotted to three pens of ten cattle each. The cattle were previously fed oat hay or oat haylage for 134 days and then brought to a full feed of whole shelled corn. The cattle were fed this ration during the 41-day trial to serve as a partial vitamin A depletion period and to get the cattle to weights where they would be finished for slaughter after 4 weeks of vitamin A supplementation. Slaughter was about 2 weeks following the last vitamin A dosing.

The procedures for administering supplemental vitamin A were as outlined in trial I. Samples of blood were collected by jugular vein puncture at the start of the trial and at the end of the trial. Liver tissue was taken at slaughter. Carotene and vitamin A analyses were performed on all samples.

Results

Chemical assays of the premixes used in these trials indicated that the freshly manufactured premix contained 350,000 IU vitamin A compared to the label of 325,000 IU per gram. The older premix was labeled 30,000 IU vitamin A per gram. However, two chemical analyses showed that the premix contained only 15,000 and 14,239 IU per gram.

Trial I

The results of the first trial are shown in table 1. Levels of vitamin A in blood plasma at the start of the trial indicate adequate vitamin A nutrition. Carotene levels in blood plasma also reflect adequate intakes of carotenoid precursors of vitamin A. Blood levels of vitamin A at the end of the 56-day trial were essentially of the same magnitude as those taken initially. Massive doses (600,000 IU per steer weekly for 4 weeks) increased the level of vitamin A in the blood only slightly.

Liver stores of vitamin A for unsupplemented cattle averaged 32 mcg per gram of fresh tissue. Livers from cattle given the recently manufactured premix contained 47 mcg per gram and 38 mcg per gram for those given the older premix. These differences are relatively small. Supplementation with each premix resulted in only a samll amount of storage of vitamin A in the liver as compared to the unsupplemented group. Biological potency did not appear to be lowered with the older premix as might have been expected from the results of the chemical assay.

Trial II

The results of the experiment are presented in table 2. Initial blood plasma levels of carotene and vitamin A would be considered adequate for finishing beef cattle. Samples collected after the last dose of vitamin A varied in carotene content between the experimental treatments. Reasons for this are not apparent. Plasma vitamin A levels were of the same general magnitude as those taken prior to vitamin A administration.

Analysis of liver tissue gave vitamin A values of 15 mcg per gram of tissue for cattle not receiving a vitamin A supplement. Cattle receiving massive doses of the newer or fresher product had liver vitamin A levels averaging 36 mcg, while the livers of cattle dosed with an older, stored vitamin A premix contained 34 mcg per gram of tissue. Liver stores with unsupplemented cattle were apparently lowered during the time cattle were in the feedlot. Both sources of vitamin A premix increased liver stores over those of unsupplemented cattle, indicating the biopotency of each premix was adequate to facilitate storage of the vitamin. The older premix appeared to supply enough vitamin A potency to contribute to liver storage of the vitamin, even though chemical analyses showed approximately a 50% reduction in biopotency.

Summary

Two trials involving 50 beef cattle were conducted to evaluate the potency of a recently manufactured vitamin A premix and a older premix held in storage. Massive doses of each premix (600,000 IU per steer per week for 4 weeks) were administered by bolus. Blood plasma and liver vitamin A concentrations were used as measures of biopotency.

The older vitamin A premix containing 30,000 IU per gram when assayed by chemical methods showed approximately a 50% loss of biopotency. When this premix was administered to fattening beef steers at the same total unitage as a recently manufactured premix, blood plasma vitamin A levels were essentially the same. Liver storage of vitamin A was about the same for each premix in trial I and trial II. However, liver stores of vitamin A in unsupplemented cattle were lowered only slightly in the first trial but markedly in the second trial as compared to cattle receiving the vitamin. The results of trial II indicate vitamin A liver storage with vitamin A supplementation and that the biopotency of the older, stored premix was about equal to the fresher premix.

Evaluations of differences in biopotency of vitamin A should be made under conditions in which vitamin A stores in the livers of unsupplemented animals are lowered or depleted to lower values than observed in these experiments prior to administration of massive doses of vitamin A. Under such conditions the response to supplementation would be a more sensitive measure of the vitamin A potency of products.

Table 1. Results of Trial I
(October 22 to December 22, 1976--56 Days)

	No vitamin A	Vitamin A premix 325,000 IU/g	Vitamin A premix 30,000 IU/g
No. of cattle	6	7	7
Avg. init. wt., lb.	1044.3	1041.3	1041.7
Avg. final wt., lb.	1161.0	1152.0	1146.6
Avg. total gain, lb.	116.7	110.7	104.9
Average Initial Blood Plasma Values--Nov. 24, 1976			
Carotene, mcg/100 ml	97.25	120.46	127.59
Vitamin A, mcg/100 ml	39.68	46.52	40.79
Average Final Blood Plasma Values--Dec. 23, 1976			
Carotene, mcg/100 ml	147.44	117.66	110.38
Vitamin A, mcg/100 ml	37.68	45.62	44.75
Average Final Liver Values--Dec. 23, 1976			
Carotene, mcg/g	3.42	3.16	3.28
Vitamin A, mcg/g	31.94	46.80	38.22

Table 2. Results of Trial II
(January 26 to March 8, 1977--41 Days)

	No vitamin A	Vitamin A premix 325,000 IU/g	Vitamin A premix 30,000 IU/g
No. of cattle	10	10	10
Avg. init. wt., lb.	1085.4	1083.0	1081.6
Avg. final wt., lb.	1145.2	1155.8	1142.2
Avg. total gain, lb.	59.8	72.8	60.6
Average Initial Blood Plasma Values--Feb. 1, 1977			
Carotene, mcg/100 ml	133.66	108.19	101.12
Vitamin A, mcg/100 ml	42.83	40.67	40.37
Average Final Blood Plasma Values--March 1, 1977			
Carotene, mcg/100 ml	132.96	57.91	84.22
Vitamin A, mcg/100 ml	36.41	39.94	44.30
Average Final Liver Values--March 7, 1977			
Carotene, mgc/g	2.87	2.19	2.43
Vitamin A, mcg/g	14.53	36.23	33.74